or physiography. They are also free from the controversial matter which is rather obtrusive in the chapters on Highland schists and Old Red Sandstone. We must congratulate the author also on the excellence of the illustrations, most of which are from photographs. Many of them are very beautiful and appropriate, and should be of great help to those who are not specially versed in geological literature. An exception may be made in the case of some of the photomicrographs of rock sections, which are not up to the general high standard of the book. A really good geological map of the area described is also a desideratum which should be supplied if the book reaches a second edition, as we hope it will.

J. S. F.

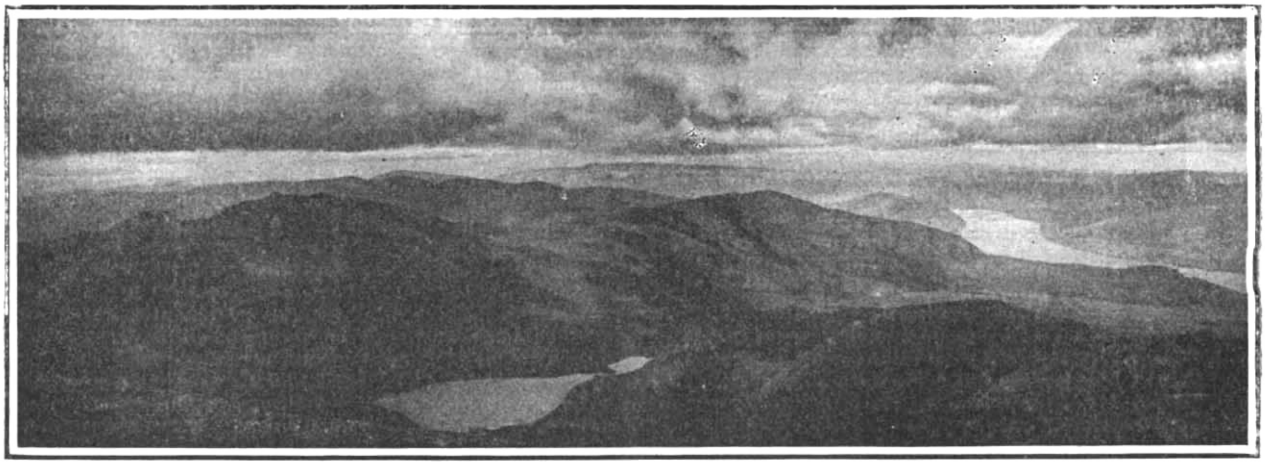

Photo. by W. L. Howie

FIG. 2.—View from the summit of Ben Lawers looking north-east along the great axial line of folding. From "The Geology and Scenery of the Grampians."

THE LICK OBSERVATORY-CROCKER ECLIPSE EXPEDITION, JANUARY, 1908.

BY the courtesy of Prof. Campbell in furnishing advance proofs of Lick Observatory Bulletins Nos. 131 and 132, and from preliminary reports published by himself[1] and Dr. Albrecht,[2] we are able to form an idea of the perfect organisation of, and the results obtained by, the expedition from Lick Observatory which went to Flint Island to observe the total eclipse of the sun of January 3.

The whole of the expenses of the Lick expedition was defrayed by Mr. W. H. Crocker, this making the ninth occasion on which his generosity has rendered such an expedition feasible. The party was conveyed from Tahiti to Flint Island by the U.S. gunboat *Annapolis,* and arrived at the latter place, which is in latitude 11° S., and is 450 miles N.W. of Tahiti, on December 9, thus leaving twenty-four clear days for the erection and adjustment of the instruments. In addition to the Lick party, consisting of Prof. Campbell, Messrs. Perrine, Aitken and Albrecht, and Mrs. Campbell, the expedition included Prof. Lewis, of Berkeley, and Prof. Boss, and was accompanied by an expedition dispatched by the Smithsonian Institution; the latter consisted of Prof. Abbot and his assistant, Mr. A. F. Moore, who were charged with the task of making bolometric observations of the coronal radiations. Readers of NATURE will remember that this island was also selected by Mr. F. K. McClean as the *locale* of the expedition which he fitted up and carried through at his own expense, and Prof. Campbell remarks that they (the McClean party) were found to be "helpful and congenial companions."

The programme of the Lick observers comprised the determination of the contact times, the photography of the corona, on large and small scales, and of the coronal and chromospheric spectra, and a photographic search for any possible intra-mercurial planet. As Mr. McClean has already reported, the weather on the morning of the eclipse was extremely sensational, rain falling in torrents between five minutes before and two or three seconds after the commencement of totality, but happily the clouds dispersed, and the remainder of the eclipse was observed in a comparatively clear sky. That results were obtained which are likely to provide valuable additions to our knowledge of solar physics may be inferred from the following brief *résumé* of the preliminary reports of the observers.

The observations of the contacts showed that mid-eclipse took place some 27 seconds earlier, whilst totality lasted some 9 seconds less, than the predicted times.

In the intra-mercurial planet research two quadruple sets of cameras were employed, each set so arranged as to include an area 9° broad and 28° long in the direction of the sun's equator. Three hundred star images, going down to the ninth magnitude, were recorded, and all have been identified with known stars by Prof. Perrine. It now seems certain that no planet brighter than the seventh magnitude exists nearer the sun than Mercury, and, as it would need a large number of seventh-magnitude planets to account for the outstanding anomalies in the motion of Mercury, Dr. Albrecht considers that the observational side of this research should now be considered as closed. The *raison d'être* of the Mercury anomalies must be sought elsewhere; possibly, as suggested by Prof. Seeliger, the material responsible for the Zodiacal Light may be sufficient to account for them.

With the Floyd camera, having a Clark lens of 5 inches aperture and 67 inches focal length, fed by a 12-inch cœlostat, eight exposures, varying from "instantaneous" to 16 seconds, produced excellent negatives showing streamers two solar diameters in length. These long streamers are rather evenly distributed around the sun, but the strong inner corona is much more intense on the east and west than at the poles.

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[1] Publications of the Astronomical Society of the Pacific, No. 119, April, 1908.

[2] The Journal of the Royal Astronomical Society of Canada, vol. ii., No. 3, p. 115.

Prof. Campbell and Dr. Albrecht speak very highly of the simplicity and the performance of the 40-feet "tower camera" of 5 inches aperture, designed by Prof. Schaeberle for the 1893 eclipse. Fig. 1 is reproduced from an illustration accompanying the former's report in the Publications of the Astronomical Society of the Pacific, and shows the instrument, in position, at Flint Island. Many advantages are claimed for this form of "direct" instrument; among them the removal of the lens and a greater part of the tube from the ground region of intense atmospheric tremor, and the elimination of the possible distortion of a cœlostat mirror are not the least. Six exposures, varying from 2 to 64 seconds, were made, and the negatives show a wealth of coronal details. The chromospheric stratum is shown on the first and last photographs, and there is a large eruptive prominence in position-angle 214°. About fifteen streamers extending to 1½ lunar diameters and a similar number extending to 1 lunar diameter are shown on the longer exposures. An unusually straight and slender streamer starts near the south point and extends, not radially, but in the direction of 190°, for about 1½ diameters; during the last seven-ninths of its length this streamer is accompanied by a fainter branch which makes an angle of 4° with its axis. Comparisons of the photographic brightness of the corona, effected by impressing standard squares on some of the plates, show that almost all the effective photographic light came from the inner corona situated within 1′ or 2′ of the moon's edge.

A plate exposed, in a spectrograph with the plate continuously moving, for fifteen seconds on either side of the end of totality, shows a spectrum in excellent focus from λ 3800 to λ 5100 the linear scale being such that from λ 3700 to λ 5300 is 13 inches. Hundreds of bright lines, showing the depths and locations of the corresponding vapours, are recorded, and should furnish a wealth of information as to the sun's higher atmosphere.

A spectrograph fitted with quartz lenses, and prisms, of 9·2 cm. aperture and 1 metre focal length, was employed by Prof. Lewis to obtain photographs of the spectra of the corona and the "flash." A sliding diaphragm in front of the slit permitted comparison solar spectra to be obtained on the same plate, and an exposure of 3¼ minutes on the corona, with the slit tangential to the east limb, and a shorter exposure on the chromosphere were made immediately before, and at, third contact. The unexpected curtailment of totality caused the latter to be over-exposed, but some eighty chromospheric lines are seen projecting beyond the solar spectrum; the resulting spectra are some 14 cm. long from λ 3000 to D. Both the continuous and the line radiations of the corona are shown, and both apparently emanated from the inner corona within a region of less than a quarter of a radius from the photosphere. Fifteen certain, and ten doubtful, lines are recorded, and of the former those at λλ 5304, 3602·3 and 3390·7 are the strongest, the respective intensities being 10, 15 and 30. That neither Huff, in 1900, nor Dyson, in 1900, 1901 and 1905, recorded the strong line at λ 3602·3, and that the latter obtained lines not shown on his own spectra, is taken by Prof. Lewis as evidence supporting the idea of a variable corona.

In discussing the relative temperature of the corona, Prof. Lewis employs the principle enunciated by Stokes in 1876, and used by Lockyer in his researches on stellar temperatures. This principle depends upon a comparison of the relative amounts of the ultra-violet and the red radiations in the light-sources examined, predominance of the former denoting higher, and of the latter lower temperature. In Lockyer's stellar work it was found that by the assumption of this law the previous results depending upon the chemical classification of the stars were plenarily confirmed, and Prof. Lewis's conclusions are no less regular. Comparing the coronal with the solar spectrum, he finds that the latter is, relatively, much richer in violet light, and says, "hence it may be inferred that the corona is considerably colder than the sun." Subsequent comparative tests with a standard candle, allowing for the atmospheric absorption of the ultra-violet radiations, fix the lower limit of coronal temperature at considerably more than 2000° absolute.

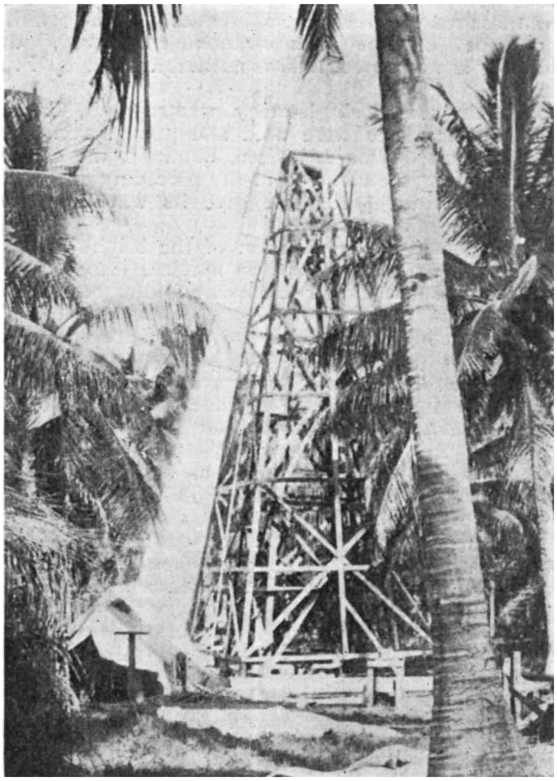

Fig. 1.—The 40-ft. Coronagraph.

Some eighty-two chromospheric lines, between λλ 3199·8 and 4863·0, with identifications from Rowland's tables and Dyson's eclipse paper, are given, but, with only the tips of the lines projecting from the dense, over-exposed spectrum, the wave-lengths are, naturally, only approximate.

For the examination of polarisation effects in the corona, four exposures, varying from two to six seconds each, were made with each of the four cameras arranged for this purpose. Each photograph shows marked polarisation in all parts of the corona, and a comparative study of the series should, incidentally, produce valuable information concerning the effect of clouds on such photographs, for during one exposure a cloud passed over the southern half of the corona, leaving the northern half cloud-free.

With two single-prism spectrographs, specially designed by Prof. Campbell, three photographs of the coronal spectrum were obtained, the slits being placed east and west across the centre of the solar image. With the first, a good spectrum of the extreme inner corona, extending from λ 3550 to λ 5390, was obtained during an exposure of 3m. 40s. Both the line at λ 5303 and an apparently new line at λ 3601·3, also obtained by Prof. Lewis, are recorded strongly, each extending to 3′ from the west, and 2′ from the east, limb; the line at λ 3987·0 is faintly, and that at λ 4231·5 is easily, visible, whilst another apparently new, and faint, line shows at λ 3625·5. The absorption lines are seen most readily in the regions lying between 10′ and 20′ from the limb, but are quite faint in the outer, and apparently absent from the inner, corona. A comparison of the continuous spectrum with solar spectra taken with the same instrument at Mount Hamilton indicates, again, a lower temperature for the former, although, in the absence of further details as to the similar treatment of the photographs considered, this evidence is not so conclusive as that educed by Prof. Lewis.

With the second single-prism spectrograph, Cramer isochromatic plates were used and good spectra, extending from λ 3600 to λ 6000, obtained, the general features being the same as in the preceding spectrum. Measures of the green line give its wave-length as 5301·4±0·5.

Owing to the inter-diffusion of the bright-line, the continuous, and the absorption spectra, these coronal spectrograms are rather difficult to interpret, but it appears certain that the radiations of the outer corona, of, say, more than 20′ from the moon, are either not recorded at all or are masked by the diffused spectrum of the brighter inner corona. The proportion of the light radiated by the coronal particles at this eclipse appears to have been relatively great as compared with the amount of sunlight diffused by them, but whether this is due to variability in the corona or to the interference of light clouds at the previous eclipses is a question which Prof. Campbell and Dr. Albrecht leave for future consideration. To those observers who had had previous eclipse experience, the outer corona on this occasion appeared disappointingly faint.

It is unnecessary here to enter into the numerous details given by Prof. Abbot concerning his bolometric apparatus, but several important modifications of that previously employed had been made for this eclipse, chiefly with the object of restricting the operative radiations during each observation to that definite, small area of the corona that was under actual observation. Preliminary observations of the relative brightness of the sun, of the sky at different distances from the sun, and of the moon were made before eclipse day, and the results are shown below. Tests were also made of the quality of the light from each of these sources, the criterion being the proportional transmissibility of the various rays by an ashphaltum screen. For sun, sky and moon the proportions of light transmitted were 0·29 to 0·37, 0·25 and 0·50 respectively, the difference sky–moon being due, presumably, to the size and nature of the reflecting particles. These results lead to the inference that if the brightness of the corona be due merely to reflected ordinary sun rays, the transmissibility of the rays will be greater if the reflecting particles be of the grossness of those composing the lunar surface, and less if they are minute like the molecules of gases.

During the eclipse, observations were made with the sun in six different positions in regard to the cross-wires of the finder, the latter being crossed to form angles of 75° and 105°. In positions i. and ii. the moon's image was tangent in one of the obtuse angles, and in iii. in one of the acute angles; this meant that in i. and ii. the bolometer was central on points 4′ of arc beyond the extremities of a lunar diameter inclined 52°·5 to the E. and W. diameter; whilst in iii. the distance of the moon's limb was about 12′ of arc. In positions iv. and v. the wires were 1′·5 of arc beyond the extremities of the moon's diameter, east and west respectively, and in vi. they intersected at the centre of the dark moon. The observations showed that the transmissibility of the inner coronal radiations, which passed through a screen transmitting light of less wave-length than 3 μ, was 0·364; on the same day the mean transmissibility of the solar radiations was found to be 0·332. The whole of the reduced results are collected in the following table, taking the sun's brightness as 10,000,000 :—

	Brightness
Sun, near zenith (Flint Island)	10,000,000
Sky, 20° from sun ,, ...	140
,, distant from sun ,, ...	31
,, average ,, ...	62
,, ,, previously measured at Mount Wilson	15
Corona, positions iv. and v.	13
,, ,, i. ,, ii.	4
Moon, about zenith distance 50° (Flint Island)...	12 (?)

In positions iii. and vi. the galvanometer showed no deflection.

Several significant facts appear from these figures, of which two call for special mention. The first is that at sea-level (Flint Island) the sky is some four times as bright as observed at an altitude of 1800 metres (Mount Wilson), thus showing the profound importance of establishing our observatories in the higher altitudes. Secondly, the brightness of the sky at 20° from the sun is to that of the corona as 140 : 13; nearer the sun the ratio would be enormously increased, and it therefore appears that to obtain photographs of the corona without waiting for an eclipse is unpromising, to say the least.

Summing up the evidence now available, Prof. Abbot believes that the best explanation of the character of the coronal radiation is that it is, in the main, due to reflected sunlight. The apparent absence of polarisation need not weaken this supposition, for, owing to the fact that they receive light from the solid angle of a whole hemisphere of the sun, the particles of the inner corona would be partially polarised in many directions, and therefore exhibit no definite polarisation in any one. The observed modification of the reflected solar spectrum may be due to the fact that the bright emissions from the heated particles close to the sun are sufficient to obliterate the absorption lines; further out the particles would be cooler—perhaps mainly solid and liquid—and the emission spectrum would then diminish, the absorption spectrum, as a consequence, appearing gradually. But as the light is still reflected sunlight only its intensity would diminish and its character and transmissibility would remain the same, as the observations show that they do.

Whilst recognising fully the difficulty of accounting rigidly for all the observed phenomena, Prof. Abbot concludes that in all probability the brightness of the corona is mainly due to reflected ordinary sunlight, diluted to some extent by the emissions from incandescent particles, and possibly, also, by some small amount of "luminescence" such as produces the aurora.

WILLIAM E. ROLSTON.